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E2 - 10520

S.B.Gerasimov

ON THE INCLUSIVE ELECTROPRODUCTION OF NEW PARTICLES AND MULTIMUON EVENTS

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Обсуждаются способы экспериментальной проверки возбуждения цветных степеней свободы адронов и проверки внутренней и пространственной симметрии в глубоко-неупругом μN -взаимодействии, приводящем к образованию многомюонных состояний. Подчеркивается важность разделения наблюдаемого сечения на продольную и поперечную часть для проверки образования цветных глюонов и динамического проявления нового масштаба масс, связанного с наличием в нуклонах "тяжелых" партонов.

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Сообщение Объединенного института ядерных исследований. Дубна 1977

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Introduction

The discovery of the weak neutral currents, heavy hadrons with new quantum numbers and, possibly, new charged leptons, as well as the necessity of the experimental discrimination between the basic alternatives underlying the unified gauge theories of the weak, strong and electromagnetic interactions, cannot but focus attention on the pertinent aspects of the deep-inelastic lepton-hadron processes.

In this note we discuss mainly the multimuon production processes

$$\mu + N \rightarrow \mu + \mu^{\pm} + X \qquad (1)$$

$$\mu + N \rightarrow \mu + \mu^{+} + \mu^{-} + X \qquad (2)$$

with the emphasis on those features of the reactions (1) and (2) which could help to choose between two basically different cases: the permanently confined versus unconfined "colour" (i.e., whether or not the coloured objects - quarks, diquarks, massive gluons, etc., may appear as free physical particles).

The first experimental results on the reactions (1) and (2) have recently been presented/1/ and discussed/2-5/ with conclusion that the data are suggestive on the charmed particle production; but for them to be conclusive, much improved statistics is needed.

With respect to reactions (1) and (2) we shall assume hereafter that the background muons from the known electrodynamic processes including possible contribution from suggested "heavy" leptons (this mechanism deserves great attention on its own right) can be evaluated and subtracted, and the "prompt" muons not coming from π - and K-meson decays can be selected and analyzed.

Excitation of New Hadronic Degrees of Freedom and Value of R (Longitudinal to Transversal Cross-Section Ratio).

In the models with the "explicit" colour the integer-charged, massive, unstable quarks, gluons, diquarks, etc., may be produced in lepton-hadron interactions. The spontaneous breaking of gauge symmetry induces mixing between the colour ("strong") and flavour ("weak") gauge bosons/6/. This, in turn, results in the leptonic and semi-leptonic decays of gluons which are , therefore, one of the sources for the direct leptons in all reactions where coloured particles are produced. Thus, the observation of "prompt" muons in reactions (1) and (2) will indicate the excitation of new hadronic degrees of freedom comprising either heavy "charmed" hadrons or coloured particles, or both. To clear up the question of the gluon production in the multimuon reactions (1) and (2), we propose to measure separately the longitudinal and transversal parts of the dimuon production cross section

$$\frac{d\sigma\left(\mu(k_1)\to\mu(k_1')+\mu(k_2)\right)}{d\Omega_1'\, dE_1'\, dk_2} = \Gamma_t\left(\frac{d\sigma_T}{dk_2}+\epsilon\,\frac{d\sigma_L}{dk_2}\right), \quad (3)$$

where the indices "I" and"2" refer to the "leading" and "produced" (say, with opposite sign of charge) muon

$$\Gamma_t = \frac{\alpha}{2\pi^2}\cdot\frac{2M\nu-q^2}{2Mq^2}\cdot\frac{E_1'}{E_1}\cdot\frac{1}{1-\epsilon} \quad (4)$$

$$\epsilon = \left[1+2\left(1+\nu^2/q^2\right)\tan^2\theta/2\right]^{-1}. \quad (5)$$

and averaging over the azimuthal angle of the produced muon is understood.

The production of gluons gives the dominant contribution to the logitudinal part of cross section

$$R^{glue} = d\sigma_L / d\sigma_T \xrightarrow[q^2 \to \infty]{} \infty \quad . \tag{6}$$

In Eq. (6) the integration over the phase space of the produced muon may be accomplished to improve the statistics.

Note that the misidentified background muons coming from π/K decays originate from the muon deep inelastic process where σ_L/σ_T has a small value.

If the prompt muons originate mainly from lepton-heavy quark (Q=c,b(?)...) interaction, then

$$R^Q = d\sigma_L / d\sigma_T \xrightarrow[q^2 \to \infty]{} 0 \quad . \tag{7}$$

We would remark, however, that the scattering on the free Dirac particle with mass M_Q gives

$$R^Q_{free} = \frac{\sigma_L}{\sigma_T} = \frac{4M_Q^2}{q^2} \tag{8}$$

and at $q^2 \sim M_Q^2$ the substantial value of R^Q would be natural in the case of the heavy quark excitation. But, eventually, $R^Q \to 0$ in the limit $q^2 \to \infty$. For the purpose of orientation and with the limited statistics one can proceed in the "simplified manner", and assuming approximate scaling behaviour for corresponding structure functions, to study the y-distribution (especially, the "high-y tail" , $y = \nu / E_1$) of the inclusive cross section

$$\frac{d\sigma}{dy} \sim \frac{1}{y^2}\left(1 - y + y^2/2(1+R)\right) \tag{9}$$

which is sensitive to the R-value. In Eq. (9) the partial integration over dropped kinematical variables can be made. For typical values $\bar{x} \simeq 0.1$, $E_1 = 250$ GeV, W_{thr}(new particles) $\simeq$ 4-6 GeV we get from Eq. (9) $\langle y^3 \rangle = 0.012$ and 0.007 for $R=0$ and $R \to \infty$, respectively.

To conclude, the observation of large (of an order of unity or larger) and nonvanishing with $q^2 \to \infty$ values of R in the multimuon processes, like Eqs. (1)-(2), would result in the far-reaching consequences. In particular, the currently popular explanation of the " $\bar{\nu}$ -anomalies"[7] via the new, right-handed weak currents and new heavy b-quark excitation ($M_b \simeq 5$-6 GeV)[8] could be revised.

Test of the SU(4) Symmetry at Small Distances

The introduction of the charmed c-quark ($Q_c = 2/3$, $m_c \simeq 1.5$-2 GeV) is justified by many reasons and leads to the extension of the SU(3) to the SU(4) as a new internal symmetry group. As far as $m_c \gg m_{u,d,s}$, the SU(4) is badly broken. Is it restored at small distances of the scale $\ell \ll m_c^{-1}$?

One can mention in this respect that if the weak and e.m. currents do not excite the coloured degrees of freedom, and the SU(4) is valid, the following relation[9]

$$F_{1(2)}^{\mu p}(x,q^2) + F_{1(2)}^{\mu n}(x,q^2) = \frac{5}{18}\left(F_{1(2)}^{\nu p}(x,q^2) + F_{1(2)}^{\nu n}(x,q^2)\right) \quad (10)$$

holds, which can be tested with isoscalar nuclear targets (like D, ^{4}He, C^{12}, etc.). The relation (10) is known to fullfil below the charmed hadron threshold. We expect it will be broken above the threshold at moderately high q^2, but it could be restored in the limit $q^2 \to \infty$. Verification of this tendency is very important for the interpretation of the charge-symmetry and scaling violations in the deep-inelastic neutrino reactions and the J/ψ - and D-meson production (hence, the "prompt" leptons) in hadron collisions.

Charge Asymmetry Effects

The model have recently been suggested in which the "physical" unstable quarks decay with breaking both of lepton and baryon quantum numbers, the decay products being containing charged leptons, but not anti-leptons (or vice versa)[6].

Then, due to the contribution of the electrodisintegration process

$$N + \mu \to \mu + 3q \to \mu + \text{leptons} + \text{mesons} \quad (11)$$

one can expect for the charge asymmetry in the total multimuon production cross section:

$$d\sigma(\mu+N\to\mu+\mu^-+X)/d\sigma(\mu+N\to\mu+\mu^++X)\neq 1 \qquad (12)$$

which can be confronted with data.

P-Odd Effects

It is known that the parity-violation effects can be observed in the inclusive reaction $\mu+N\to\mu+X$ through the difference of interactions of the incoming lepton with positive and negative helicities on unpolarized target. Recording an additional particle (muon) in the reaction (1) enables to look for the P-odd effects without the helicity reversing of incoming muon. The general structure of the azimuthal dependence (φ being the angle between the normals to the planes formed by 3-vectors $k_1+p\to k_1'+(k_2+p_X)$ and $q+p\to k_2+p_X$, $q=k_1-k_1'$,respectively) of the dimuon cross section can be written as follows/10/:

$$\frac{d\sigma}{d\varphi}=a+b\cos\varphi+c\sin\varphi+d\cos2\varphi+e\sin2\varphi \qquad (13)$$

Observation of $c\neq0$ and/or $e\neq0$ is due to the parity nonconservation and admits, at least in principle, experimental verification.

More generally, without assuming the lowest order approximation in weak and e.m. coupling constants from which Eq.(13) follows, one can look for the asymmetry $A=(N_+-N_-)/(N_++N_-)$ where $N_\pm$ is the number of the dimuon events with the positive (negative) value of the parity violating correlation function $P=(\vec{k}_1\cdot[\vec{k}_1'\times\vec{k}_2])$ of the lepton momenta (its manifestly T-noninvariant form may not imply A=0 due to the strong interaction effects in the reaction (1)).

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